Book of the Short Papers

Editors: Francesco Maria Chelli, Mariateresa Ciommi, Salvatore Ingrassia, Francesca Mariani, Maria Cristina Recchioni

SIS Società Italiana di Statistica

UNIVERSITÀ POLITECNICA DELLE MARCHE

Dipartimento di Scienze Economiche e Sociali DISES

LIUC Università Cattaneo

LIUC Università Cattaneo | BUSINESS ANALYTICS AND DATA SCIENCE HUB

Pearson

CHAIRS

Salvatore Ingrassia (Chair of the Program Committee) - *Università degli Studi di Catania*
Maria Cristina Recchioni (Chair of the Local Organizing Committee) - *Università Politecnica delle Marche*

PROGRAM COMMITTEE

Salvatore Ingrassia (Chair), Elena Ambrosetti, Antonio Balzanella, Matilde Bini, Annalisa Busetta, Fabio Centofanti, Francesco M. Chelli, Simone Di Zio, Sabrina Giordano, Rosaria Ignaccolo, Filomena Maggino, Stefania Mignani, Lucia Paci, Monica Palma, Emilia Rocco.

LOCAL ORGANIZING COMMITTEE

Maria Cristina Recchioni (Chair), Chiara Capogrossi, Mariateresa Ciommi, Barbara Ermini, Chiara Gigliarano, Riccardo Lucchetti, Francesca Mariani, Gloria Polinesi, Giuseppe Ricciardo Lamonica, Barbara Zagaglia.

ORGANIZERS OF INVITED SESSIONS

Pierfrancesco Alaimo Di Loro, Laura Anderlucci, Luigi Augugliaro, Ilaria Benedetti, Rossella Berni, Mario Bolzan, Silvia Cagnone, Michela Cameletti, Federico Camerlenghi, Gabriella Campolo, Christian Capezza, Carlo Cavicchia, Mariateresa Ciommi, Guido Consonni, Giuseppe Ricciardo Lamonica, Regina Liu, Daniela Marella, Francesca Mariani, Matteo Mazziotta, Stefano Mazzuco, Raya Muttarak, Livia Elisa Ortensi, Edoardo Otranto, Ilaria Prosdocimi, Pasquale Sarnacchiaro, Manuela Stranges, Claudia Tarantola, Isabella Sulis, Roberta Varriale, Rosanna Verde.

FURTHER PEPOPLE OF LOCAL ORGANIZING COMMITTEE

Elisa D'Adamo, Christian Ferretti, Giada Gabbianelli, Elvina Merkaj, Luca Pedini, Alessandro Pionati, Marco Tedeschi, Francesco Valentini, Rostand Arland Yebetchou Tchounkeu

Technical support: Matteo Mercuri, Maila Ragni, Daniele Ripanti

PUBLISHED BY PEARSON
WWW.PEARSON.COM
ISBN 9788891935618AAVV

Contents

Statistical Machine Learning for environmental applications

Statistical Process Monitoring for Complex Data in Industry 4.0

Advances in Data Science and Statistical Learning [IMS Invited Session]

ENBIS Session: System Maintenance, Boosting algorithms for regression, and Research Excellence

Educational Data mining: methods for complex data in students' assessment

Spatial and Spatio-Temporal Modeling: Theory and Applications

Statistical Framework for Measuring the Sustainability of Tourism

Statistical learning for well-being analysis

Statistics in Society 1

Assessment and Education

Bayesian methods and applications 1

Health and mortality

Mixture Models

Sampling methods and analysis of survey data

Space-time statistics

Clustering and classification 1

Dynamic models and time series

Environmental learning and indicators

Health statistics 2

Migrants in Italy and return migration

Sustainability assessment

Bayesian methods and applications 2

Clustering and classification 2

Economics and labour markets

Environmental modeling

Multivariate data analysis 2

Statistics in Society 2

Bayesian methods and applications 3

Functional Data Analysis

Machine Learning and text mining

Multivariate data analysis 3

Nonparametric statistical methods

Regression modeling

Sex Gap in Cancer-Free Life Expectancy: The Association with Smoking, Obesity and Physical Inactivity

Alessandro Feraldi[a], Cristina Giudici[b] and Nicolas Brouard[c]

[a] Department of Statistical Sciences, Sapienza University of Rome; alessandro.feraldi@uniroma1.it
[b] MEMOTEF Department, Sapienza University of Rome; cristina.giudici@uniroma1.it
[c] National French Institute for Population Studies (INED), Paris; brouard@ined.fr

Abstract

We measured sex-specific total life expectancy, cancer-free life expectancy (CFLE), and years spent with cancer according to the (co-) occurrence of three behavioural risk factors, such as smoking, obesity and physical inactivity. We examined differences between women and men using data from the United States Health and Retirement Study 2008–2018 and we applied multistate lifetable approach for each combination of smoking, obesity, and physical inactivity, controlling for education. Risk factors were associated with shorter CFLE, the shortest observed in current smoker's men and women (-4.7 years at age 50). Reductions of CFLE in physically inactive people was higher in women (-3.3 years) than in men (-2.3 years) and obesity had a significant effect only in women (-3.1 years). Sex differences decreased at older age. The (co-) occurrence of behavioural risk factors reduces the CFLE disadvantage of men compared to women.

Key words: sex gap, cancer-free life expectancy, mortality risk factors

1. Introduction

Cancer is second leading cause of death globally. According to the United States Cancer Statistics (USCS), around 16.9 million men and women had a cancer history in the United States (US) in 2019 and there are projected more than 22.0 million cases in 2030 (USCS 2019). In 2019, the prevalence of cancer in women and in men was 4.0% and 3.8%, respectively. Prostate, breast, lung and bronchus, and colorectal cancer are the most frequently diagnosed cancers in the US (USCS 2019). Although improvements in cancer survival due to advances in screening technology and implementation and treatments in recent decades, cancer still contributes significantly to years lived with disability and to the risk of mortality.

Studies have shown that modifiable lifestyle factors such as smoking, physical activity, alcohol intake, body weight, and diet quality affect both life expectancy and incidence of chronic diseases, including cancer (Stenholm et al 2016; Leskinen et al 2018). Nevertheless, little research has looked at how multiple behavioral risk factors may affect life expectancy free from the major diseases, especially free from cancer (i.e. Cancer-Free Life Expectancy - CFLE).

Using data from Nurses' Health Study and the Health Professionals Follow-Up Study in 1980–2014, Li and colleagues (Li et al 2020) estimated CFLE according to five healthy behaviours in the US They showed that at age 50, compared to women with healthy behaviours, women with unhealthy behaviours can expect to live 8.3 year less without cancer, whereas this difference was 6.0 years in men. Conversely, a study of Zaninotto and colleagues in the US between 2002 and 2013, observed larger reduction in chronic disease free life expectancy (including cancer) in men than in women in case of risky behaviour (Zaninotto al 2020). Most of the existing studies have some limitations related to non-representative populations (reducing the generalizability of results), short duration of follow-up and study populations aged <75 years (Li et al 2020; Zaninotto al 2020; Leskinen et al; Leskinen et al 2018).

Accordingly, the aim of this study was to examine the extent of the reduction in CFLE due the (co-) occurrence of risk factors such as smoking, obesity and physical inactivity, in a nationally representative

longitudinal survey of older people (aged 50 and over) in the United States. Additionally, we study the sex gap in CFLE and in the association with multiple risk factors, with a follow-up of 10+ years. The number of years lived without cancer is estimated with health expectancy outcomes, a measure that combines incidence and mortality to estimate life expectancy lived with and without cancer. Taking into account both morbidity and mortality, estimates of life expectancy free of cancer provide useful metrics for health professionals and policy makers in order to better estimate future healthcare costs of cancer and to plan for healthcare needs.

2. Data and methods

Data were retrieved from the Health and Retirement Study (HRS) in the US, an ongoing nationally representative longitudinal study on health, behavioural risk factors and wealth, in which people have been interviewed approximately every two years, from 1992 to 2018. In the HRS database, mortality follow-up is ascertained through linkages to the National Death Index and reports from survivors. We used data from 2008 (baseline) to 2018 and we included people aged 50+ with valid data on cancer and behavioural risk factors. At each wave of the study respondents were asked 'has a doctor ever told you that you have cancer'. This information was used to assess the presence of cancer at each wave, which includes any cancer conditions reported before the age of 50 from available information on respondents. In this study, all individuals in the sample had information on the presence of cancer at baseline (2008). Participants who had missing lifestyle factors at baseline were excluded (423 individuals, 2.5%). The resulting analytical samples included 16,438 aged 50 years and older (out of the 16,861 HRS members aged 50 years and older in 2008).

Smoking status was dichotomized into "Never or former smoker" and "Current smoker". Obesity was measured according to self-reported Body Mass Index (BMI) and dichotomized as "obese" (BMI $\geq$ 35 Kg/m2) and "not obese" (BMI < 35 Kg/m2). Frequency of moderate physical activity was used to assess physical inactivity, which was dichotomized as "physically inactive" if taking part in moderate physical activity for less than one day a week and "physically active" otherwise. The co-occurrence of multiple behavioural risk factors was defined as reporting 2 or more risks.

We used multistate Markov survival models to estimate how participants moved between no cancer (state 1), cancer (state 2), and death (state 3) states. This model had three possible transitions: no cancer to cancer, no cancer to death, and cancer to death. Participants who developed cancer could only move from the disease state to the death state. Age-specific transition rates were modelled using multinomial logistic regression using as covariates age and behavioral risk factors (smoking, obesity and physical inactivity); years of education was included as controlling variable. Separate models were specified for women and men. Sex-specific transition rates are then applied to a synthetic cohort in order to summarize them into duration: Total Life Expectancy (TLE); Cancer-Free Life Expectancy (CFLE) - expected average number of remaining years of life with no cancer; and Cancer Life Expectancy (CLE) - expected average number of remaining years of life expected to live in cancer states.

Sex gap in Cancer-Free Life Expectancy was calculated as absolute difference: females minus males. Transition rates were estimated with the *msm* R package (Jackson 2011) and R package Estimating Life Expectancies in Continuous Time (*ELECT*) was used in order to estimate state-specific life expectancies conditional on reaching age 50 years (van den Hout, Chan & Matthews 2019). Confidence intervals were estimated using 1000 bootstrap samples.

3. Preliminary findings

The sample includes 9,606 women (54.6%) with a mean age of 67.8 years and 6,832 men (45.4%) with a mean age of 66.7 years (p=0.07). At age 50, the average number of years that people can expect to live without cancer was 30.6 years in women and 26.8 years for men. The overall sex gap in CFLE at age 50 was 3.9 years. At age 50, a woman with no cancer at baseline could expect to live on average 36.2 years of remaining life expectancy, whereas remaining life expectancy was shorter to 29.5 years for a woman with cancer. Men with no cancer at age 50 can expect to live 33.3 years, whereas men with cancer can expect to live only 27.7 years.

Figure 1 shows life expectancy free from cancer over age, according to the occurrence of behavioral risk factors, for women (panel a) and for men (panel b). At age 50, CFLE was 33.7 years in women and 28.6 years in men with no behavioral risk factors. Compared to this group, in presence of behavioral

risk factors, years of life expected to leave without cancer were lower in both women and men: respectively, 28.9 and 24.0 for smoking, 30.6, 30.3 and 23.6 for physical inactivity, and 26.1 and 22.8 years for 2 or more risk factors. Compared to people with no risk factors, being current smokers was associated with the shortest CFLE in both sexes: approx. 4.7 fewer years free of cancer at age 50. Obesity had a significant effect on cancer-free life expectancy only in women (3.1 fewer years). Similarly, reductions of CFLE in physically inactive people was higher in women (3.3 years) than in men (2.3 years).

Panel c in Figure 1 displays the sex gap in CFLE according to behavioral risk factors. Compared to no risk factors, the presence of risk factors was associated with a smaller sex gaps in CFLE. At age 50, the difference in CFLE between women and men with no risk factors was around 5.0 years. The CFLE sex gap was similar for smoking (4.9 years at age 50), whereas it was smaller to 4.0 years for physical inactivity, 3.4 years for multiple risk factors, and the lowest for obesity, 1.2 years. Differences between women and men were narrower at older ages.

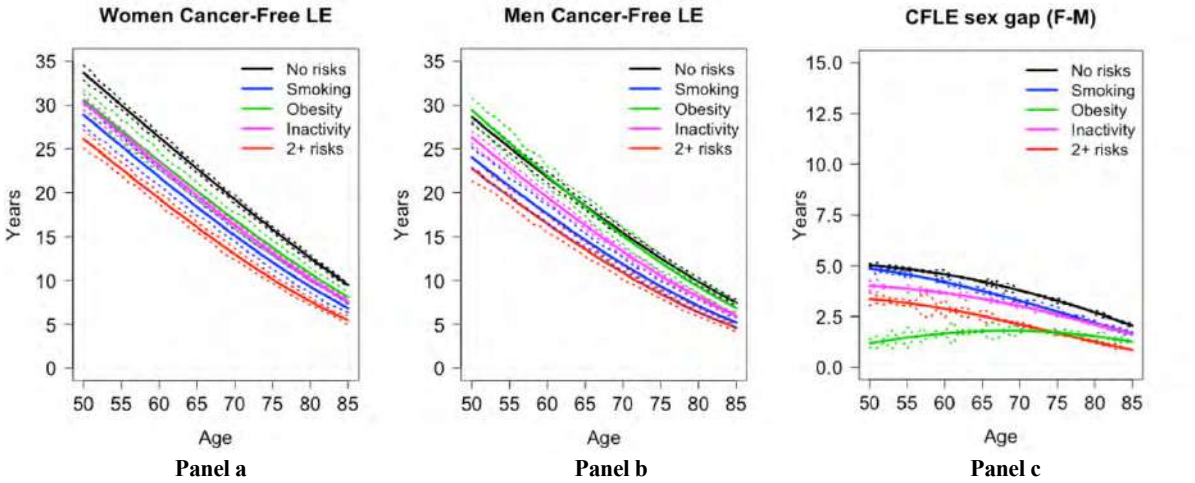

Figure 1: Women (panel a) and Men (panel b) Cancer-Free Life Expectancy (CFLE) and sex gap (Female (F) CFLE - Male (M) CFLE, panel c) in CFLE over age, according to behavioral risk factors.

4. Conclusion

Using a nationally representative study of ageing in the US, we showed that behavioural risk factors were associated with reduced remaining number of years spent without cancer. Reducing smoking and obesity, and increasing physical activity among older people could potentially lead not only to longer lives but also healthier lives (free of cancer). Compared to men, women live on average more years free of cancer (about 3.0 years on average between age 50–85). Additionally, the (co-) occurrence of risk factors reduces the cancer-free life expectancy disadvantage of men with respect to women, especially at younger ages. The results of this study provide useful metrics for health professional and policy makers in the quantification of future healthcare costs of cancer and in the plan for healthcare needs.

References

[1] Leskinen, T., Stenholm, S., Aalto, V., Head, J., Kivimäki, M., & Vahtera, J. (2018). Physical activity level as a predictor of healthy and chronic disease-free life expectancy between ages 50 and 75. *Age and Ageing*, *47*(3), 423-429.

[2] Li, Y., Schoufour, J., Wang, D. D., Dhana, K., Pan, A., Liu, X., ... Hu, F. B. (2020). Healthy lifestyle and life expectancy free of cancer, cardiovascular disease, and type 2 diabetes: prospective cohort study. bmj, 368.

[3] Sonnega, A., Faul, J. D., Ofstedal, M. B., Langa, K. M., Phillips, J. W., & Weir, D. R. (2014). Cohort profile: the health and retirement study (HRS). *International journal of epidemiology*, *43*(2), 576-585.

[4] Stenholm, S., Head, J., Kivim¨aki, M., Kawachi, I., Aalto, V., Zins, M., ... Vahtera, J. (2016). Smoking, physical inactivity and obesity as predictors of healthy and disease-free life expectancy between ages 50 and 75: a multicohort study. International journal of epidemiology, 45(4), 1260-1270.

[5] U.S. Cancer Statistics Working Group. U.S. Cancer Statistics Data Visualizations Tool, based on 2021 submission data (1999–2019): U.S. Department of Health and Human Services, Centers for Disease Control and Prevention and National Cancer Institute; www.cdc.gov/cancer/dataviz, September 2022.

[6] van den Hout, A., Chan, M. S., Matthews, F. (2019). Estimation of life expectancies using continuous-time multi-state models. Computer methods and programs in biomedicine, 178, 11-18.

[7] Zaninotto, P., Head, J., Steptoe, A. (2020). Behavioural risk factors and healthy life expectancy: evidence from two longitudinal studies of ageing in England and the US. Scientific Reports, 10(1), 1-9.